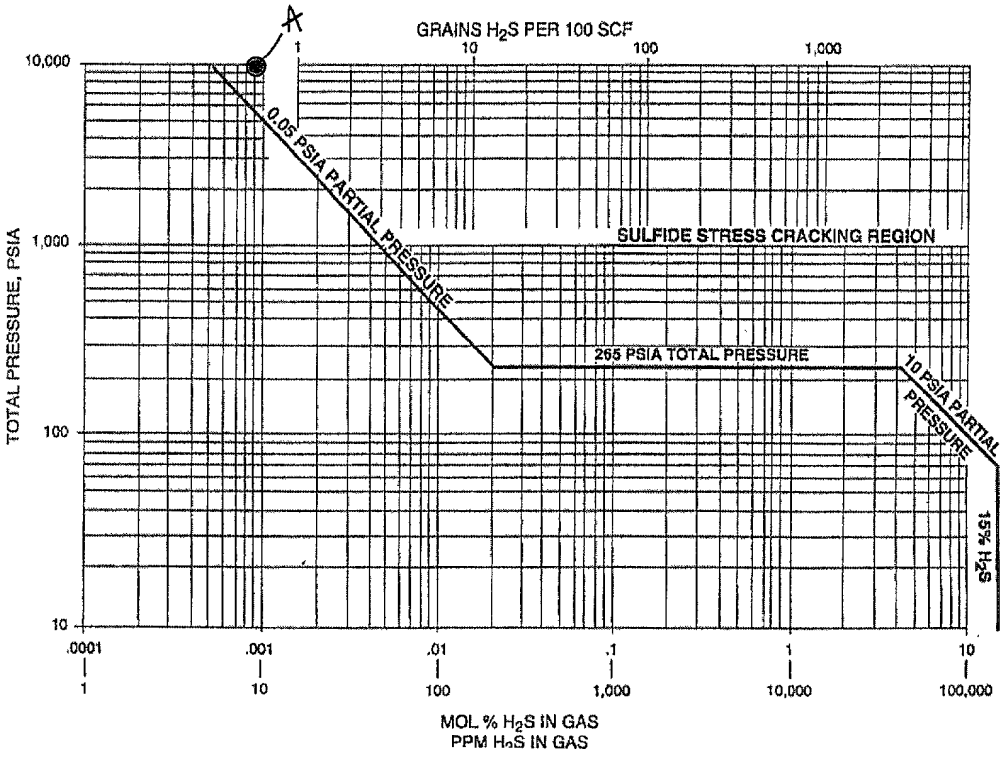

A
GRAINS H_2S PER 100 SCF
1
10
100
1,000
10,000
1,000
100
10
TOTAL PRESSURE, PSIA
0.05 PSIA PARTIAL PRESSURE
SULFIDE STRESS CRACKING REGION
265 PSIA TOTAL PRESSURE
10 PSIA PARTIAL PRESSURE
15% H_2S
.0001
.001
.01
.1
1
10
1
10
100
1,000
10,000
100,000
MOL % H_2S IN GAS
PPM H_2S IN GAS

Fig. 1

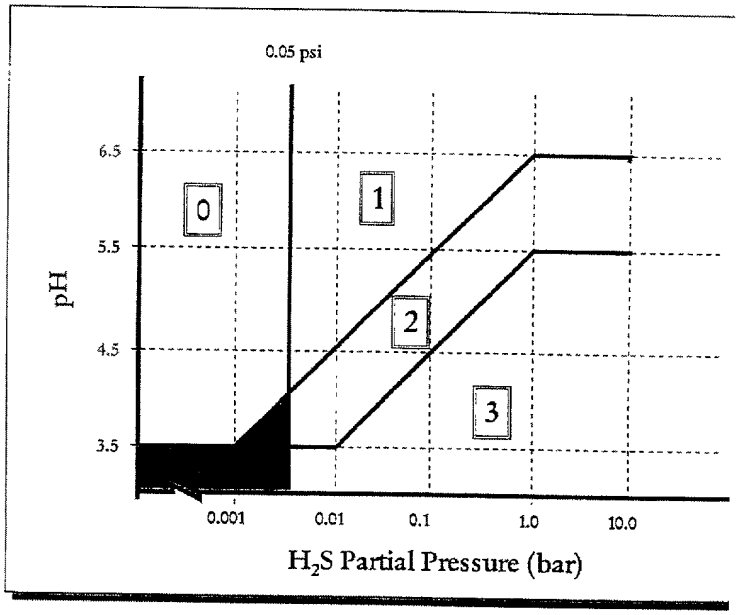

0.05 psi
6.5
5.5
4.5
3.5
pH
0
1
2
3
0.001
0.01
0.1
1.0
10.0
H_2S Partial Pressure (bar)

Fig. 2

RAW MATERIAL BAR STOCK	
ALLOY	**$/lb.**
4130	1.0
4140	1.0
9Cr	1.5
410-13Cr	2.0
420 Mod.	2.0
17-4	3.0
304	2.5
316	3.0
S13Cr	5.0
450	6.0
918	5.5
Monel K-500	12
925	11.5
718	12
625M	20
725	20
C-276	50
MP35N	60

Fig. 3

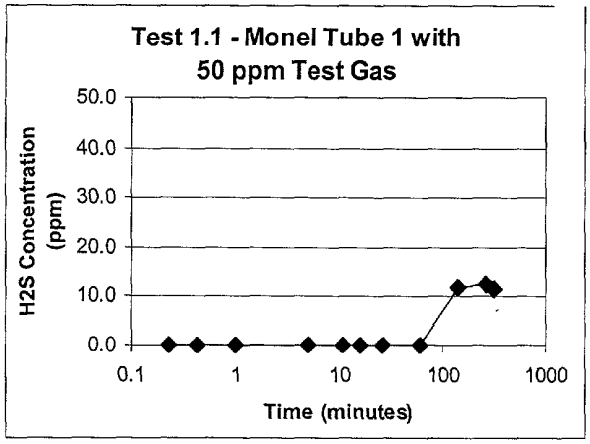


Fig. 4

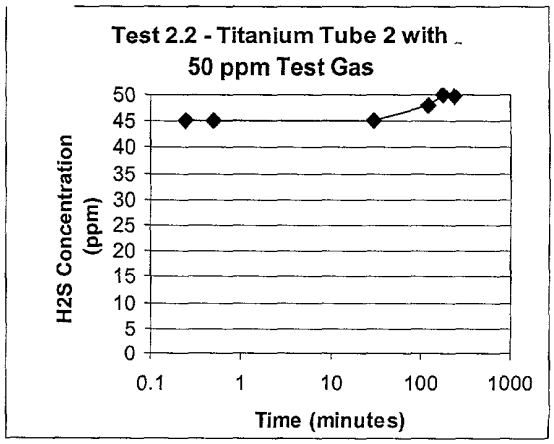


Fig. 5

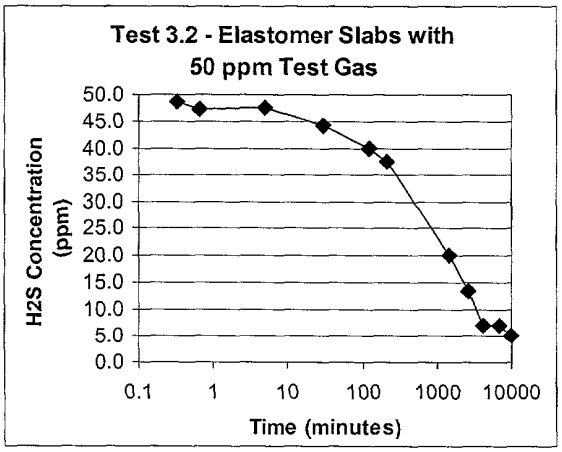


Fig. 6

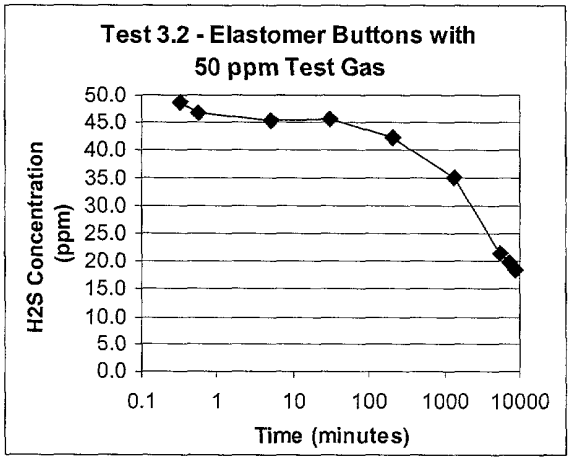


Fig. 7

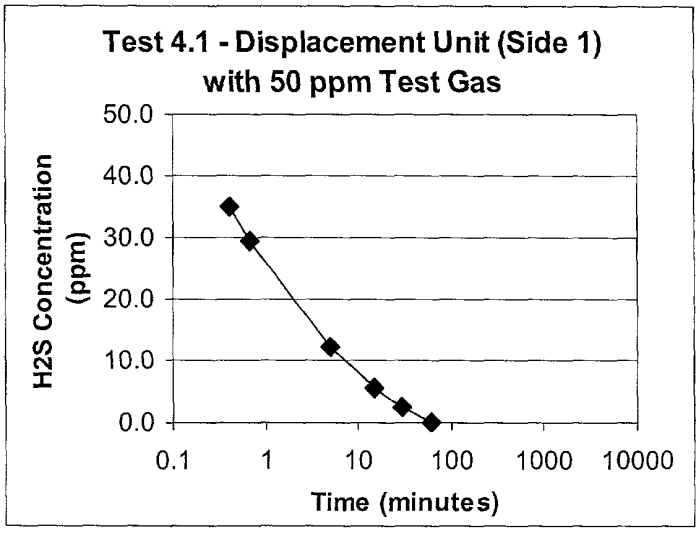


Fig. 8

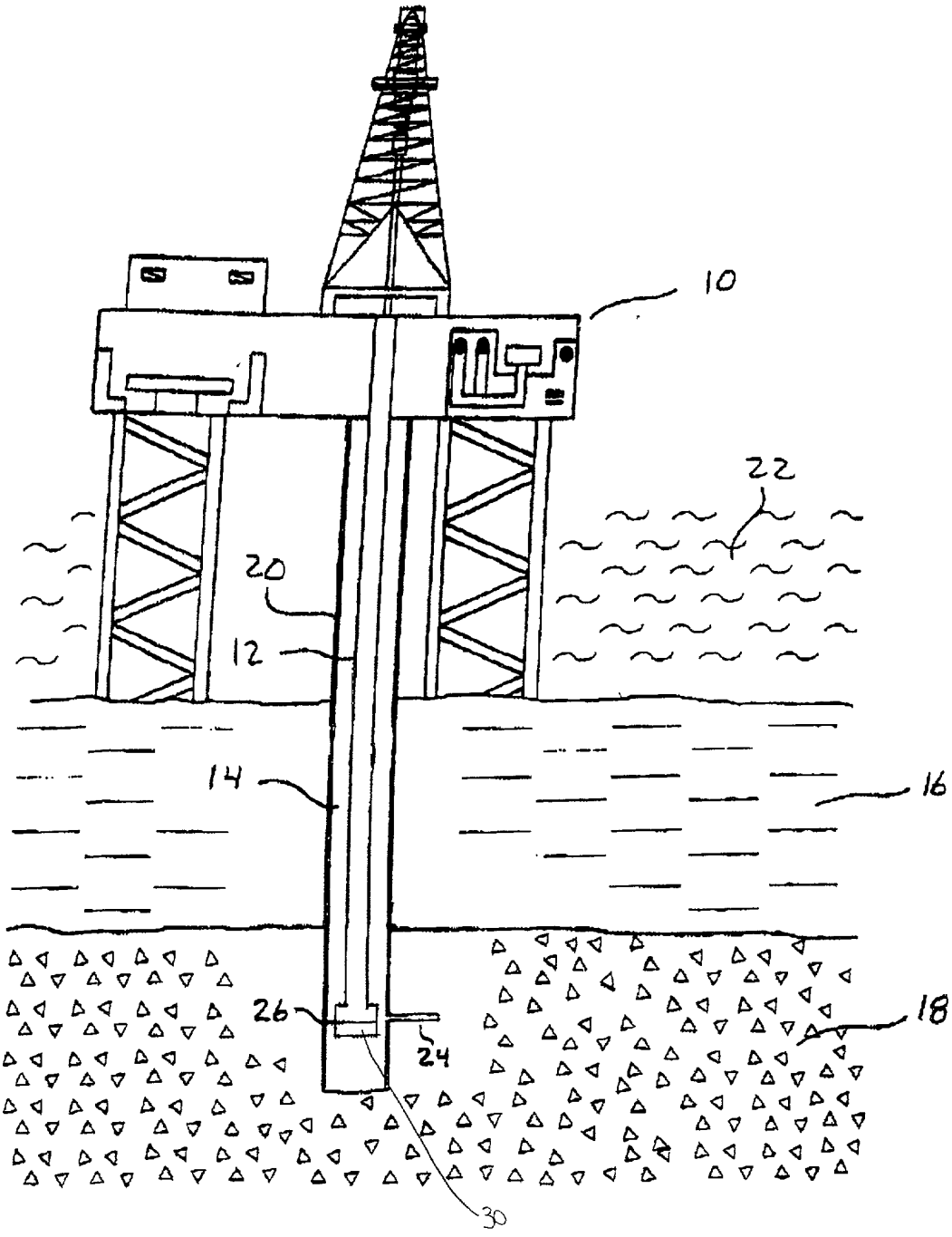


FIG. 9

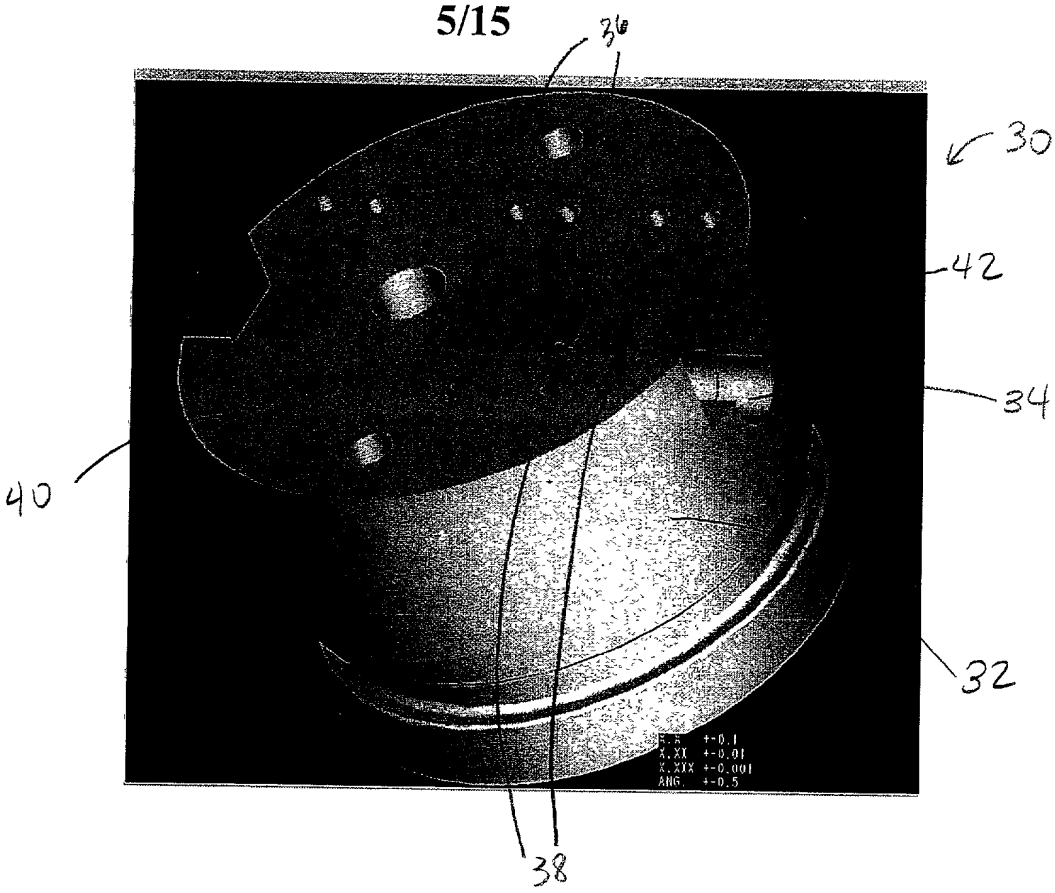


Fig. 10

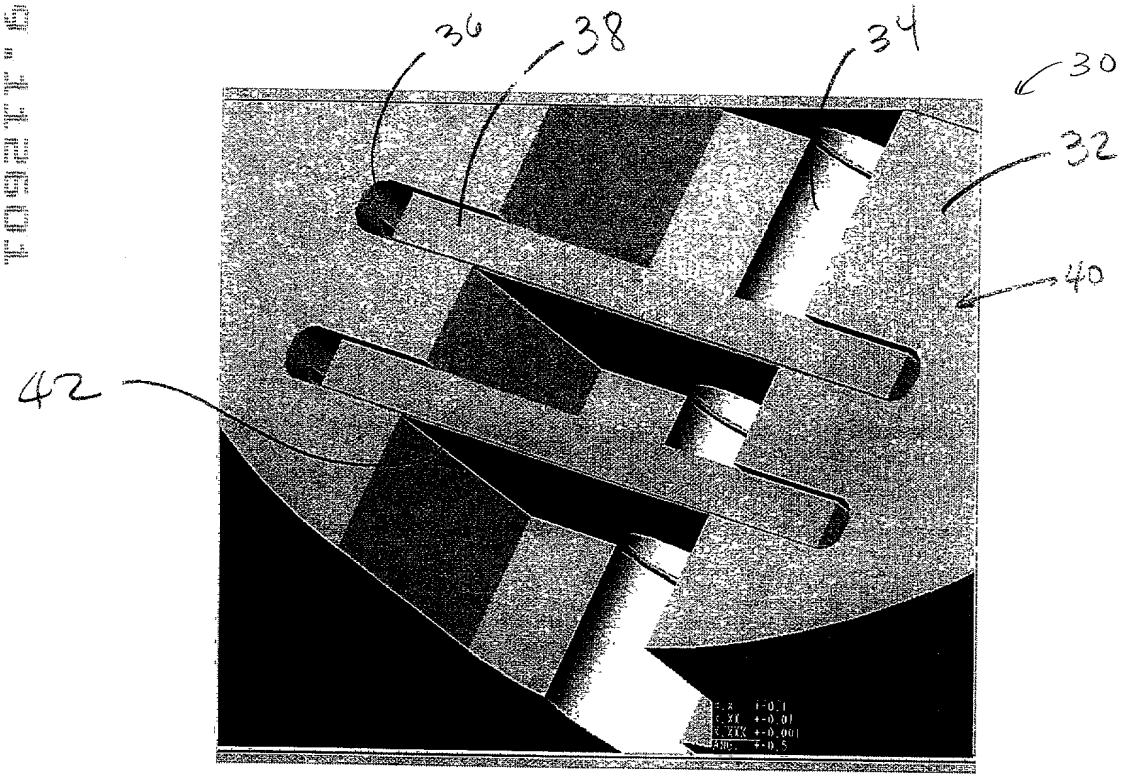
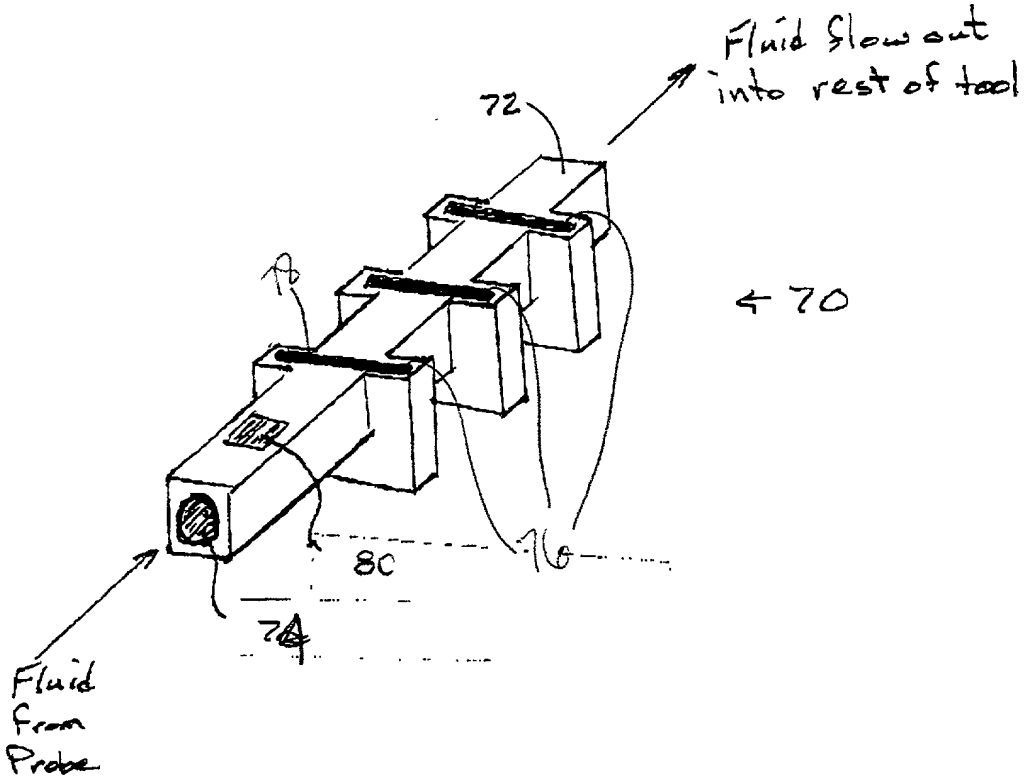


Fig. 11

Figure 12



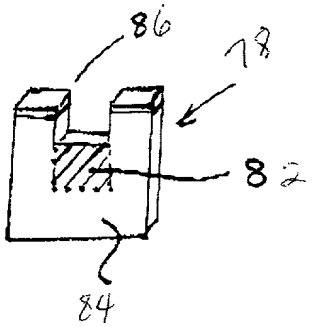
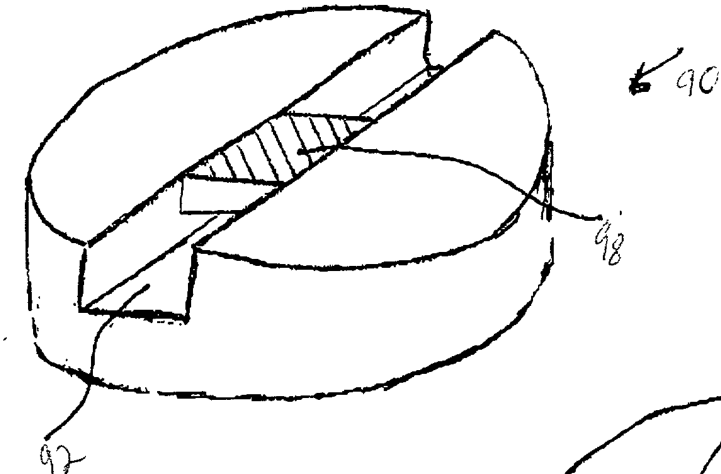


FIG. 13

FIG. 14



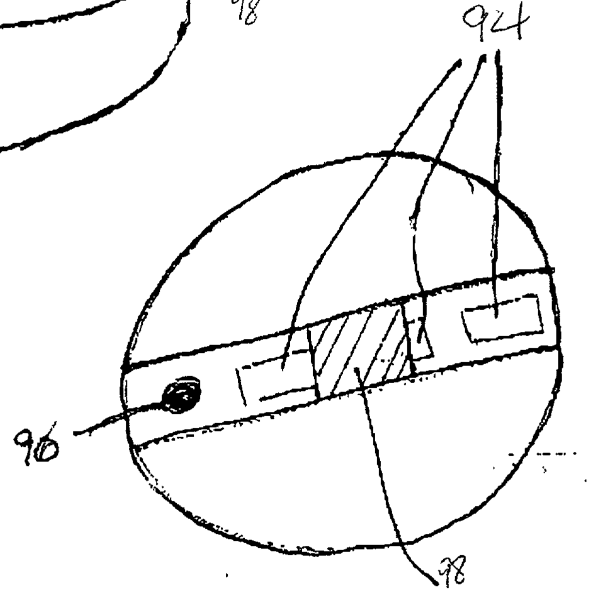


FIG 15

Fig. 16 – LIST OF MATERIALS TESTING IN THIS STUDY

(Nominal Composition in wt. Percent)

Alloy	*Ni*	*Cu*	*Fe*	*Cr*	*Mo*
Monel alloy 400 N04400	63 – 70	Bal.	2.5 max.	--	--
70-30 cupronickel C71500	29 – 33	Bal.	0.4 – 1.0	--	--
90-10 cupronickel C70600	9 – 11	86.5 min.	1.0 – 1.8	--	--
Nickel alloy 200 N02200	99.0 min.	0.25 max.	0.40 max.	--	--
Alloy B N10001	Bal.	--	6.0 max.	1.0 max.	26 – 33
Incoloy alloy 600 N06600	72 min.	.50 max.	6 - 10	14 - 17	--
5Cr steel K41545	--	--	Bal.	4 - 6	0.45 – 0.65
9Cr steel K90941	--	--	Bal.	8 - 10	0.9 – 1.1
12Cr steel S41000	--	--	Bal.	11.5 – 13.5	--

Fig. 17 – RESULTS FROM PHASE I TESTS

Test No.	*H2S (ppm)*	*Duration (hr.)*	*Temp. (F)*	*Monel 400*	*70/30 CuNi*	*90/10 Cu/Ni*	*Ni 200*	*Alloy 600*	*Alloy B*
				Condition of Coupons after Exposure					
*1**	0	6	250	O	O	ST	--	--	--
*2**	0	2	400	O	ST	ST	--	--	--
3	0	2	250	ST	ST	ST	--	--	--
4	50	2	250	G	DG	DG	--	--	--
5	0	2	300	ST	ST	ST	--	--	--
6	50	2	300	DG	G	DG	--	--	--
7	0	2	350	ST	ST	ST	--	--	--
8	50	2	350	DG	G	DG	--	--	--
9	0	2	400	ST	ST	ST	--	--	--
10	50	2	400	DG	G	G	--	--	--
11	25	2	300	DG	G	DG	--	--	--
12	25	6	300	DG	G	G	--	--	--
13	10	2	300	DG	G	G	--	--	--
14	10	2	300	DG	G	DG	--	--	--
15	5	2	300	DG	G	G	--	--	--
16	25	2	300	DG	G	DG	G	ST	DG
17	10	2	300	DG	G	DG	ST	ST	ST
18	18	2	300	DG	G	G	ST	ST	G

Note:
O – No attack
ST – Slight tarnish
G – Gray corrosion film
DG – Dark gray corrosion film

* Test contained oil mud as liquid phase

Fig. 18 - RESULTS FROM PHASE II TESTS

Test No.	*H2S (ppm)*	*Duration (hr.)*	*Temp. (F)*	*5Cr*	*9Cr*	*12Cr*	*316 SS*	*Ni 200*	*Alloy 600*	*Alloy B*
				Condition of Coupons after Exposure						
*201**	25	2	250	G	G	G	O	DG	T	B
*301**	50	2	250	G	G	G	O	G	T	G
401	25	2	250	G	G	G	G	G	G	DG
501	50	2	250	DG	DG	G	LG	G	G	DG
601	100	2	250	DG/B	DG/B	DG/B	LG	LG	B	G
701	50	2	250	DG	DG	B	LG	G	G	LG
801	75	2	250	DG	DG	DG	LG	LG	DG	G
901	100	2	300	DG	DG	DG	LG	LG	B	G
1001	75	2	300	DG	G	DG	LG	LG	B	G
1101	50	2	300	DG	DG	DG	LG	LG	B	G
1201	100	2	250	DG	DG	DG	G	G	BB	G
1301	75	2	300	G/B	G/B	G/B	G	G	B	G
1401	50	2	350	DG	DG	DG	G	G	DG	G
1501	75	2	350	DG	DG	G	G	LG	G	DG
1601	100	2	350	G/B	DG	DG	G	G	G	G

Note:
O – No attack
ST – Slight tarnish
LG – Light gray corrosion film
G – Gray corrosion film
DG – Dark gray corrosion film
B – Black corrosion film

* coupons in vapor phase

Photo Summary of H2S Coupon Study

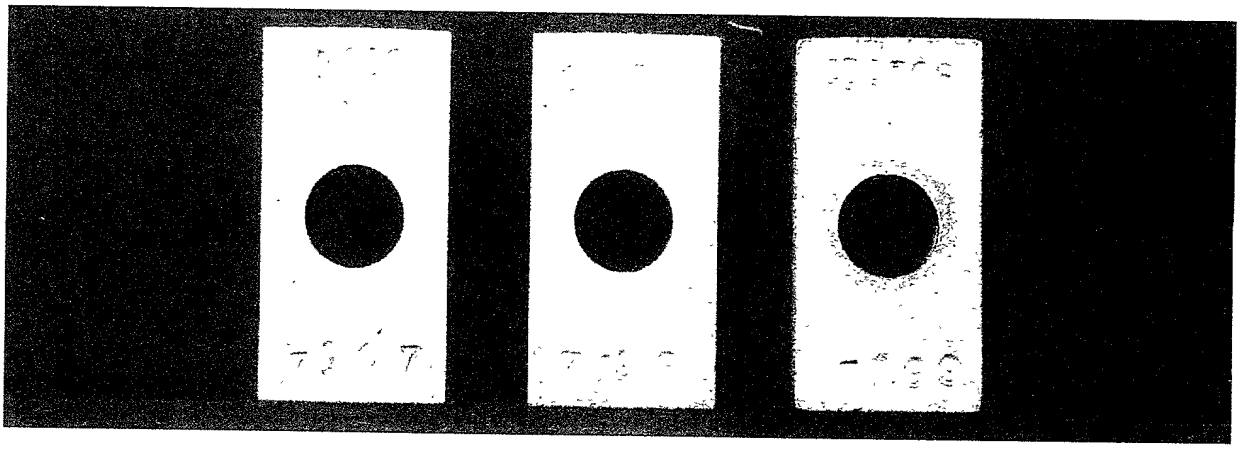


Fig. 19A Example of copper containing specimens with tarnish films from exposure – note darkening of surface while retaining shiny metallic luster

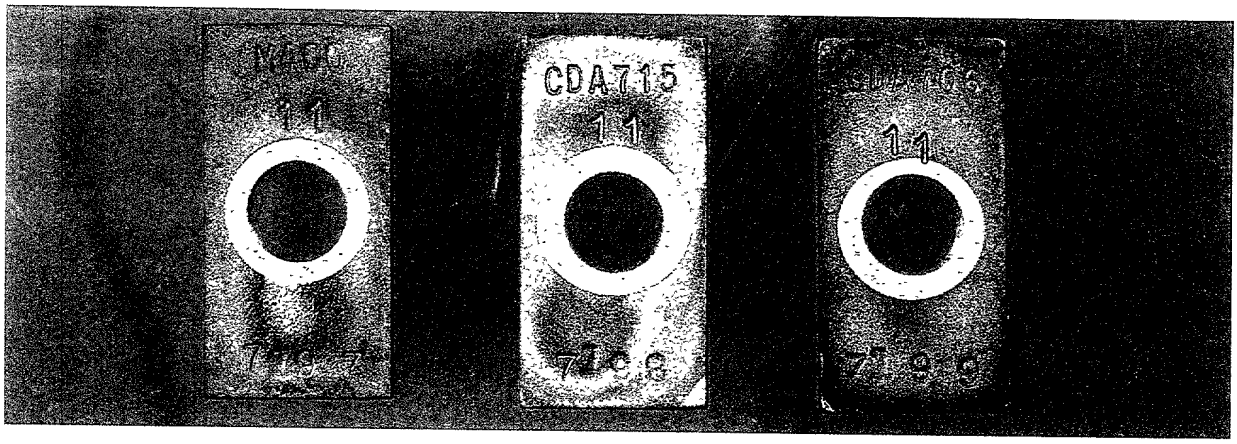
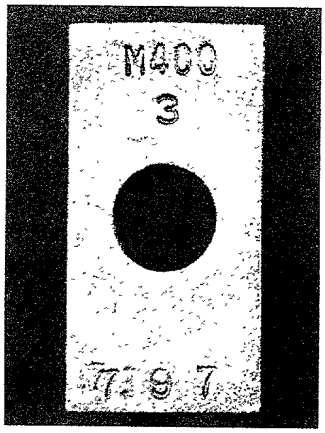


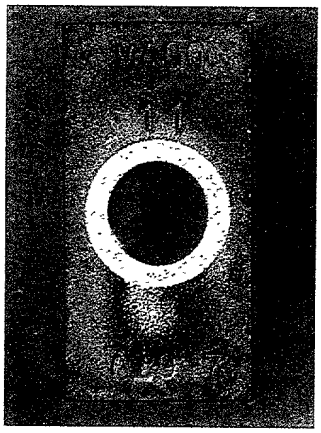
Fig. 19B Example of gray-black corrosion films on copper containing alloys – note dark surface films with no metallic luster

Change in Corrosion films on Monel with increasing levels of H2S in environment



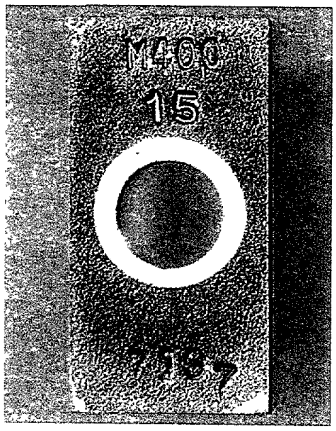
0 ppm H2S

Fig. 20A



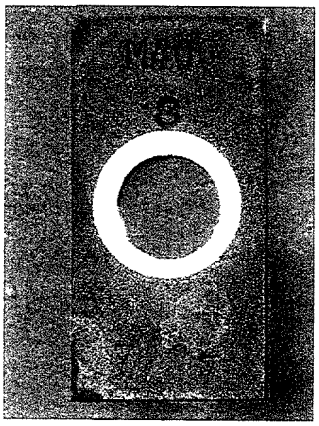
25 ppm H2S

Fig. 20D



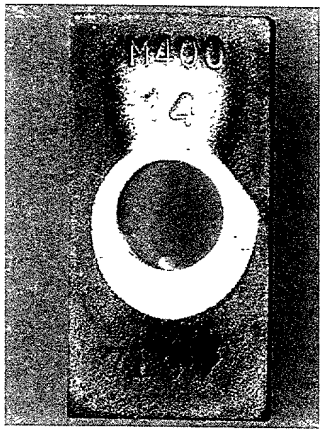
5 ppm H2S

Fig. 20B



50 ppm H2S

Fig. 20E

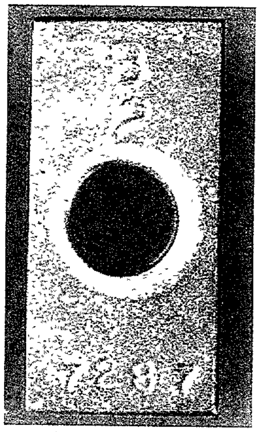


10 ppm H2S

Fig. 20C

Change in coloration from tarnish to dark gray between 5 and 10 ppm

Change in corrosion films on Alloy B with increasing levels of H2S in environment



10 ppm H2S

Fig. 21A

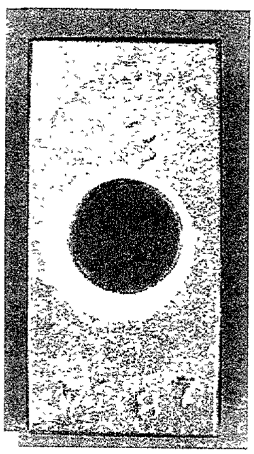
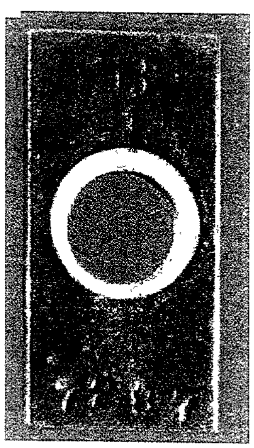
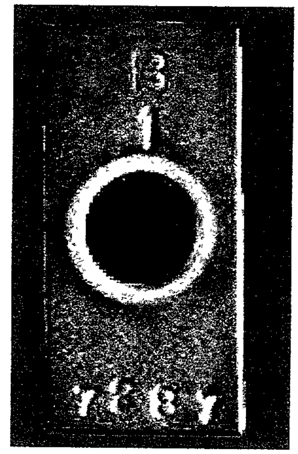


Fig. 21B 18 ppm H2S



25 ppm H2S

Fig. 21C



50 ppm H2S

Fig. 21D

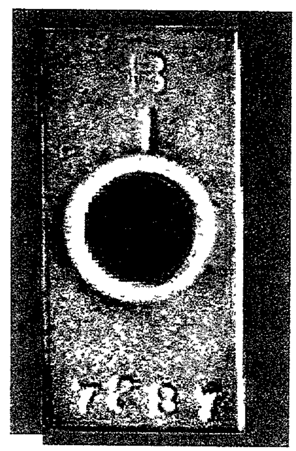


Fig. 21E 75 ppm H2S

Change in coloration from tarnish to gray between 18 and 25 ppm

Change in corrosion films on Alloy 600 with increasing levels of H2S in environment

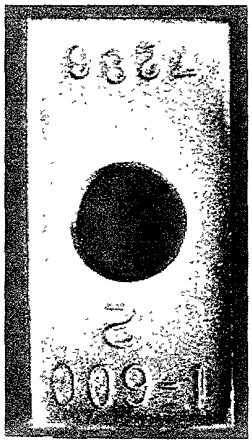


Fig. 22A 10ppm H2S

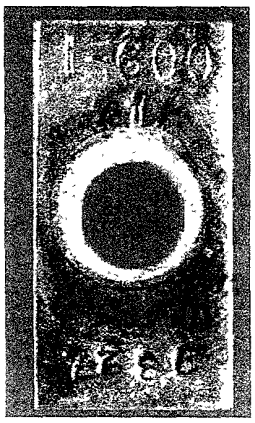


Fig. 22B 25 ppm H2S

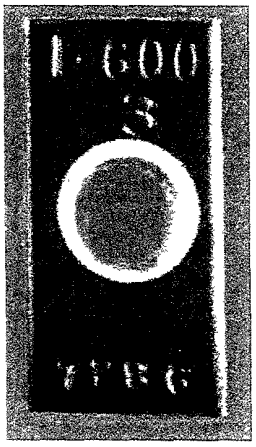


Fig. 22C 50 ppm H2S

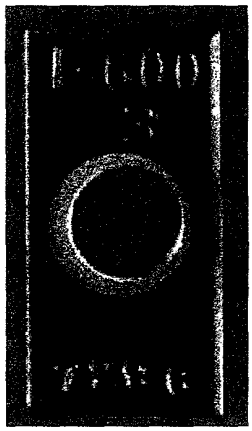


Fig. 22D 75 ppm H2S

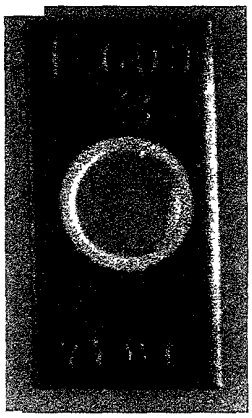


Fig. 22E 100 ppm H2S

Change in coloration from tarnish to brown/gray black between 25 and 50 ppm

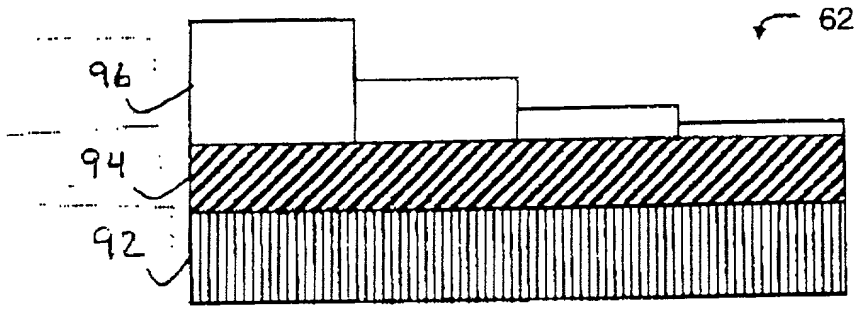


FIG. 23